THE DELORO VILLAGE

ENVIRONMENTAL HEALTH RISK STUDY

SUMMARY REPORT

July 1999

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Ontario

Ministry
of the
Environment

Deloro Village Environmental Health Risk Study
Summary Report

Introduction - The Deloro Mine Site

For nearly 100 years private mining and refining operations at the Deloro Mine Site contributed to the prosperity of Ontario. But that prosperity came with a price -- serious and extensive environmental degradation. The last owners abandoned the site in 1979, leaving a complex blend of contamination.

By the time the mining and refining operations were shut down, nearly a century's worth of hazardous by-products and residues -- a complex blend of toxic compounds, heavy metals and low level radioactive wastes -- remained on the property. The Ministry of the Environment took control of the site when the last owners abandoned the property. To date the Ministry has invested about $12 million to control contamination on site. The ministry's final remediation plan will address all contamination on site. It will take about 2-3 years to complete at an estimated cost of $18 million.

Environmental Health Risk Study - Background and Objectives

The Ministry is committed to defining the extent of any off-site environmental problems associated with the Deloro Mine Site, including the potential for contamination in the village of Deloro. Soil samples taken beyond the boundaries of the mine site in 1997 showed the presence of arsenic, cobalt, nickel, silver and other heavy metals. Airborne pollutants released during nearly 100 years of mining and refining are the most likely cause of this contamination. Some contamination may also have originated from blowing dust from the red mud mine tailings before the material was covered by the Ministry in 1987.

The sample results together with historical data from soil and vegetation sampling done in the 1980s, were assessed in a preliminary fashion in February 1998 by Ministry toxicologists, and reviewed with the local Medical Officer of Health. Information suggested that the levels of arsenic in soil in the village might be higher than had previously been measured. Additional information was needed to determine exposure levels and possible health risks in the community.

As soon as results were analyzed and the Medical Officer of Health consulted, the Ministry held a community information session to explain that a health risk study was being considered. Residents were informed about the purpose of the study and were given some details about how the study would be designed. Participation in the sampling program was voluntary but residents were encouraged to participate so that a large number of samples could be collected from locations throughout the village. The higher the participation rate, the more valid the findings of the study. (Note: Participation in the sampling program was excellent– nearly everyone participated.)

The study was launched in March of 1998 by the Ministry of the Environment, in cooperation with the Hastings and Prince Edward Counties Health Unit and the Ministry of Health.

The purpose of the health risk study was to answer the following questions:

1. Are contaminants from the former mine site present in the community and if so, at what levels?

2. What are the possible exposures that residents might have to these contaminants and how likely would it be for these exposures to happen?

3. What are the possible health implications of exposures, if any?

Scientific and Medical Expertise

In order to ensure that the study was carried out in an accurate and scientifically sound manner, the Ministry committed to using the very best expertise available. A Technical Steering Committee was set up to design and oversee the study. The Committee included senior scientists from the Ministry of the Environment and the Ministry of Labour, and medical doctors from the Ministry of Health, the Hastings and Prince Edward Counties Health Unit, and the Toronto Hospital for Sick Children. Committee members are shown in Table 1.

Senior ministry scientists – including plant and soil specialists, toxicologists, and engineers – along with a team of highly qualified and experienced consulting professionals conducted sampling and analysis. The Ministry's expert consulting firms are shown in Table 2.

In addition, the Ministry asked leading international experts from Canada and the United States to review the study reports and findings. This meticulous review was conducted to ensure that the findings were scientifically correct and to ensure that no important information or interpretation had been overlooked. External peer reviewers are shown in Table 3. For more detailed information on external peer reviewers see Appendix 1.

Table 1 Technical Steering Committee		
Individual	**Association**	**Expertise**
Mr. Scott Fleming (Study Director)	Ministry of the Environment, Standards Development Branch	Senior Toxicologist - human health risk assessment
Mr. Jim Ritter	Ministry of the Environment, Eastern Region	Senior Project Engineer, Deloro Mine Site
Dr. Lynn Noseworthy	Hastings and Prince Edward Counties Health Unit	Medical Doctor, Public Health
Dr. Michael McGuigan	Hospital for Sick Children	Director, Poison Control Center - biological monitoring of toxics
Dr. Lesbia Smith	Ministry of Health	M.D. -Environmental Health Toxicological Unit, Epidemiology
Dr. Arthur Scott	Ministry of Labour	Environmental Radiation
Mr. Murray Dixon	Ministry of the Environment	Terrestrial Effects Scientist - soil and garden sampling, plant effects
Mr. Adam Socha	Ministry of the Environment	Senior Advisor, Toxicology
Ms. Barbara Theman	Ministry of the Environment, Eastern Region	Communications Specialist
Mr. Glen Hudgin	Hastings and Prince Edward Counties Health Unit	Director, Public Health Inspections

Table 2 Consulting and Analytical Expertise	
Consulting Firm	**Expertise**
CH2M Gore & Storrie Limited (CG&S)	Engineering and Risk Assessment
Goss Gilroy Inc. (GGI)	Biological monitoring, statistical analysis
MAXXAM Analytics, Inc	Laboratory analysis of arsenic in urine
SENES Consultants Ltd. (SENES)	Radioactivity sampling and risk assessment
CANTOX Environmental Inc. (CANTOX)	Environmental Health Risk assessment
LEX Scientific Inc. (LEX)	Air and dust sampling.
CANVIRO Analytical Laboratories Ltd.	Laboratory analyses for metals
Becquerel Laboratories Inc.	Laboratory analysis for radionuclides

Dr. Sandra Rifat	Cancer statistics, epidemiology

Table 3 External Peer Reviewers

Individual	Association	Expertise
Dr. Charles Abernathy	U.S. Environmental Protection Agency	Toxicologist- arsenic health effects and drinking water
Dr. Bliss Tracy	Health Canada	Radiation Scientist -exposure and health effects of radiation
Dr. Willard Chappell	University of Colorado	Professor of Physics - arsenic exposure and health effects
Dr. Chris Le	University of Alberta	Associate Professor, Public Health,- Arsenic Exposure and urinary analysis
Dr. Buck Grisson	Centre for Disease Control, ATSDR	Toxicologist. Arsenic exposure and risk assessment
Dr. Henry Caplan	University of Saskatchewan	Professor of Physics. Environmental Radiation and Risk
Mr. Mark Gardiner	Low Level Radioactive Management Office, Port Hope	Radiation Sampling and remediation

Design of the Study

Considerations

When designing the study, the Technical Steering Committee of toxicologists and doctors considered all available technical information concerning the village and the mine site. They also looked at similar studies that had been conducted elsewhere and gave consideration to historical concerns in the community such as radon gas in homes. Various experts were consulted and additional suggestions made by the expert consulting team.

A focus questionnaire was developed and completed by several Deloro residents. Also, a door-to-door survey was conducted to identify those wishing to participate and to gather valuable information regarding personal activities in the village that could affect exposure. All information was used to focus the sampling and analysis to ensure that those factors that were most significant would be studied more intensely.

The safety of the residents of Deloro was of the utmost importance. Residents were assured during the sampling and analysis of health study results, that any samples that indicated an immediate health hazard would be reviewed with the medical doctors on the Technical Steering Committee for the study, and communicated immediately to the affected parties. These experts did not find any results that suggested a need for immediate intervention.

The Study's Approach

The Environmental Health Risk Study in the Village of Deloro uses a multimedia health risk approach. The multimedia approach to health risk assessment examines total exposure to contaminants through a number of possible pathways, such as air, soil, drinking water and food. By examining the various means of exposure, as well as the levels of exposure to a contaminant, the study not only predicts the likelihood of a health risk, it also helps identify actions needed to reduce that risk. It does not, however, provide a diagnosis of the present health status of people living in the community.

Using this approach, information gathered through environmental and biological sampling and the exposure assessment is compared against the most recent toxicological information such as available health-based guidelines for a particular substance. This information is gathered from various agencies– the World Health Organization (WHO), Health Canada, the International Agency for Research in Cancer (IARC), and the U.S. Environmental Protection Agency (USEPA), among others -- to determine the existing acceptable intake or known health criteria for a substance. The purpose is to predict the relationship between exposure to a contaminant and the likelihood of adverse effects. That is, at what dose (or intake) level are harmful effects likely to occur? Are the calculated risks negligible (minimal) or are they large enough to warrant concern?

The overall framework for this type of health risk study is shown in Figure 1.

The study in Deloro is the most comprehensive of its kind ever conducted in Ontario. Over a thousand samples were collected over an eight month period, including:

- sampling of all possible pathways of contamination – indoor and outdoor air, indoor and outdoor dust, soil, drinking water and backyard garden vegetables;
- more than 175, 000 gamma radiation readings;
- and biological monitoring (direct measurement of body arsenic through collection of urine samples) in Deloro and in a control (non-exposed) community, Havelock, Ontario. Total and speciated arsenic were analyzed for.

In addition to these basic features, an analysis was undertaken to review cancer incidence and mortality rates in Deloro and the population of the surrounding area (including downstream along the Moira River) from 1980 to 1995. The cancers studied (e.g. lung, bladder, kidney, etc.) were selected because they had been identified in the literature as being potentially associated with the contaminants present at the Deloro Mine Site or because they were relatively common cancers which could provide useful comparisons.

Also, a special environmental health risk factor questionnaire was designed and administered to Deloro (and Havelock) residents to examine possible relationships between levels of arsenic in urine and many different environmental factors including arsenic in soil and dusts, house characteristics, presence and use of vegetable garden, pesticide use, use of well water, swimming in Moira Lake, pets in the house, occupational exposure and child's environment.

Contaminants of Concern

Nine contaminants of concern were selected as the focus of the study. They are listed in the table below.

Environmental Health Risk Study - Contaminants of Concern	
Metals	**arsenic (most important), cobalt, nickel, lead, silver**
Radionuclides	**Ra226, U238**
Radon Gas	
Gamma Radiation	

The metals were selected because historical sampling from the 1980s found they were present in soil in areas surrounding the mine site, at levels elevated above background. Radionuclides and gamma radiation were surveyed because of unconfirmed suspicions that radioactive waste products from the mine site might be present in some areas of the village. Finally, radon gas was included because of the historical concern over radon gas in homes in Deloro.

A Note on Sampling

In the spring of 1998, a very detailed soil survey of the village was undertaken. This had never been done before. Based on preliminary information from this work and the pattern in which the metals seemed to be distributed, particularly arsenic, the village was divided up into four zones for analysis which are also shown. This was to be able to determine if there were any differences between areas in terms of possible exposure and risk. The study area and zones are shown in Figure 2.

Measurement of arsenic in urine was conducted in the fall of 1998 at the time when dust exposures were anticipated to be highest and dry conditions exist. This was to capture the highest possible exposures. Arsenic in urine was selected as the best method to measure recent exposures because it is sensitive to low levels of exposure, is comparable to results in other similar studies and because there are existing criteria against which the health importance of the finding can be interpreted.

Keeping the Community Informed

A committee of Deloro residents was formed to give residents the opportunity to provide input and comments on the Environmental Health Risk Study and to voice any concerns. Throughout the study, the Ministry kept residents informed through committee meetings, and regular update bulletins, and flyers that were hand delivered to residents' homes.

Summary of Major Findings

Levels of Contaminants

1. Sampling indicates that there are elevated levels of arsenic, cobalt and lead in soils and above-background levels of other contaminants including radon and gamma radiation in some localized areas of the village.

Safety

2. However, **the results of the risk study strongly indicate that there are no unsafe exposures or adverse health effects associated with the contamination in the village**. Although the levels of arsenic and other metals were found to be elevated due to the past century of industrial activity at the mine, all of the analyses and expert opinion supports the conclusion that under the range of conditions considered **it is safe to reside in the village and its homes**. The most important facts in support this overall conclusion are:

- There was no statistical difference in levels of arsenic in urine between Deloro and the comparison (unexposed) community of Havelock. Also, the levels and distribution of arsenic in urine in Deloro residents were very similar to those of Havelock.
- The levels of arsenic in urine in Deloro are not indicative of any excess levels of illness (as observed by the Deloro/Havelock residents self-reporting).
- There was no demonstrable relationship between arsenic levels in residential yards and garden soil and arsenic levels in urine.
- Estimated cancer risks from arsenic contamination are not measurably higher than those for typical Ontario residents.
- Overall predicted exposures and risks for arsenic were only slightly greater when compared to estimates for the typical Ontario resident. For example, predicted maximum cancer risk for arsenic in Deloro from all pathways totaled was less than 0.2 times higher than the maximum risk for a typical Ontario arsenic exposure (1.17 per 1000 for Deloro versus 0.963 per 1000 for Ontario). Most importantly, the percent contribution of exposure or dose from soil and dusts (dermal, ingestion and inhalation) was small when compared to arsenic in the normal daily diet. **The presence of arsenic in the Ontario diet is due to its natural occurance as a trace element in the earth and its uptake into crops.** There are also various forms of arsenic in food which are considered non-toxic or less toxic than other forms.

- If all soils in Deloro were replaced with background soils, overall risk would be reduced by only 2-4%.

- Predicted cancer and non-cancer risk levels were only slightly higher for Deloro residents than for a person living elsewhere in Ontario. For example, it was estimated that roughly 80% of lifetime exposure to arsenic in Deloro is from the normal Ontario food basket as compared to roughly 4% for soil and indoor dust combined. The relative contribution of specific pathways to total lifetime risk (e.g. backyard vegetables, diet, soil) is shown in Figure 4. The combined risk from soil, indoor dust and home garden produce is 1/10th that of the regular Ontario food basket. Furthermore, the levels of risk for each of the soil and indoor dust, and backyard vegetable pathways were found to be in the range which is considered negligible.

- Radiological exposures and lifetime cancer risks predicted for Deloro residents are comparable and in the range of exposures and risks from Ontario background radioactivity.

- The levels of contaminants in drinking water were all within objectives for safety.

- The epidemiological review of cancer incidence and mortality data in Deloro and surrounding areas (1980-1995) found that, for the cancers studied, no incidence or mortality rate was high enough to warrant more detailed analysis of the statistics.

Radioactivity

3. With respect to gamma radiation, there was one area (the vacant lot adjacent to the main entrance of the former mine site) which exceeded the Federal/Provincial guideline, but the levels were deemed not to be an immediate health concern. In the rest of the village there were only three small pockets (covering an area of no more than a few square metres) with slightly elevated gamma radiation levels, all well within safe levels. All radionuclides in soil and dusts were within the range that is typical for the rest of Ontario. A few homes were found to have higher than normal levels of radon gas, although none were above guidelines which require immediate remediation or suggest imminent hazard to health.

Study Objective One:
Are contaminants from the former mine site present at significant levels in the community?

In order to determine if contaminants from the former mine site were present at significant levels in the community the Ministry conducted a comprehensive analysis on soil, garden soil indoor/outdoor air, indoor/outdoor dust, vegetables, and drinking water, as well as a thorough investigation for gamma radiation and radon gas.

Soil Study

A total of 145 soil samples were collected from the front and backyards of all residential properties in the Village of Deloro, as well as from six properties north of Deloro Dam road and two properties west of the village, and tested for contaminants.

Soil samples in the Village of Deloro had higher arsenic, cobalt and lead amounts than the MOE's soil guideline values. The intent of these guidelines values are to indicate where more investigation is needed to determine whether the levels above the guideline are safe or not. Barium, copper, nickel, silver, strontium, uranium, and zinc were below MOE's guideline and therefore no further investigation was indicated. The average concentration of barium was not significantly different than typical levels in Ontario. The average concentration of copper was approximately half the background levels in Ontario. The average concentration of nickel was approximately 25% higher than background levels in Ontario. The average concentration of silver was approximately 10 times higher than background levels in Ontario. A map showing arsenic in soil levels throughout the village is shown in Figure 3.

Radionuclides in soil were within the range that is typical for Ontario.

Garden Soil and Produce Study

Garden vegetables and garden soil samples were collected and tested for contaminants from nearly all residential households where there was a substantial garden from which there could be vegetables eaten regularly. There were seven participants. Vegetables were planted from seed in seven Deloro gardens and vegetables were planted from seed in a field plot at the MOE Phytotoxicology laboratory in typical Ontario soil. Both sets of vegetables were harvested and tested for contaminants. The uptake of contaminants in vegetables planted in typical Ontario soil (MOE) were compared with the uptake of contaminants in vegetables planted in Deloro soil.

Soil samples from the gardens were found to contain on average arsenic levels approximately twice as high as the MOE guideline value. Cobalt, barium, lead, nickel, silver and strontium were approximately 2 to 4 times higher on average than typical levels in Ontario. Despite the presence of contaminants in soil, sampling of garden vegetables showed no significant uptake of contaminants in vegetables.

The edible portions of plants seldom accumulate high concentrations of arsenic, since plant growth is usually severely stunted before this occurs. The highest arsenic concentrations tend to be in root crops, particularly beets and radishes. Fruit crops, such as tomatoes, berries and apples, present a much lower risk because they take up and store very little arsenic. Green beans are good indicators of arsenic availability in soil, since this species is particularly sensitive to arsenic. If green beans grow well in a garden, it is unlikely that the uptake of arsenic into other vegetables in the garden will be high enough to pose a health risk. Bean pods, beet roots, carrot roots and lettuce leaves were sampled and showed no significant uptake of contaminants. Levels of uptake of arsenic in to plants was small and indicated that arsenic in Deloro soil is not readily available.

Concentrations of contaminants in most plant tissues from the Deloro plots were comparable to tissue concentrations in the laboratory plants. In one garden, contaminant concentrations were higher than other garden plots. However, concentrations of contaminants in surface soil and garden soil from this area was not unusually high relative to the conditions at the other six gardens. The soil and vegetation data were used to assist in the characterization of the potential risk of Deloro residents who may consume these vegetables.

Drinking Water Data

The Village of Deloro communal well and private wells from 15 participating residences were sampled and tested for the presence of contaminants.

The Village communal well water is safe since all testing met the Ontario Drinking Water Objectives.

Two water samples were collected from each of the private wells. One was representative of water that has sat in pipes overnight (first draw) and one after the water had been run for at least five minutes (flush sample). None of the flushed private well samples exceeded guidelines for metals or radionuclides. Two private wells detected lead in first draw (unflushed) samples above Ontario Drinking Water Objectives. This is typically a result of water piping containing lead alloys, which is the reason Health Canada recommends running tap water prior to drinking.

Indoor Air and Household Dust Data

Part of the study was to determine the risk associated with exposure (breathing in, touching and ingesting) contaminated air and dust. Swipe samples of interior surface dust were collected from each home to confirm the presence or absence of contaminants in readily accessible areas of exposure in a home. Most of these samples indicated no detectable levels of metals. However, based on knowledge from other studies, it was recognized that dusts could also be found in areas not captured by the swipe sampling, such as carpets or fabric drapes. As such, the study did not rely on the swipe sample results but rather calculated dust contaminant concentrations based on known ratios of outdoor soil to indoor dust from similar studies. Measurement of indoor dust can also be measured via a vacuum pump method, however this tends to underestimate risks so that type of sampling was not used in this study. The method used ensured that indoor dust concentrations would not be underestimated.

Sampling was completed during generally dry and dusty conditions. Since samples were collected during periods of high dust movement they are considered representative of typical conditions. Biological monitoring was also performed during this period when exposure to dust would be high.

The sampling locations for the indoor air and dust sampling consisted of 54 households, the Town hall/Library, the municipal well pumphouse, a youth centre in the Village of Deloro, and the Marmora Township office.

The levels of metals and radiological contaminants in indoor air and dust were compared to provincial and federal guidelines (where available) and reference samples collected outside the study area (control locations). Reference samples were taken for air and dust in the Marmora Township Office and at the southwest edge of the Village of Deloro. Levels of metals and radiological contaminants in general were not significantly different than levels in samples collected outside the study area (reference locations).

Outdoor Air and Dust Data

Although substantial soil data already existed in the Village to assess outdoor exposure, additional surface dust samples were collected and tested for the presence of contaminants. The surface dust data were used primarily for comparative purposes since it appeared consistent with the soil data (i.e. higher concentrations of contaminants in dust where generally found in areas of higher soil concentrations).

Ninety-eight air samples, ten road dust, ten exterior surface dust and ten outdoor dustfall samples were collected and tested for the presence of contaminants. Eight air and dustfall sampling locations were located throughout the Village and two were located outside the study area to represent reference areas. The reference areas were the Marmora Township Office and the southwest edge of the Village of Deloro.

Outdoor Air. Approximately half of the outdoor air samples detected metals but all were below provincial air quality criteria. All of the samples detected some radionuclides and although there are no specific criteria for comparison, the values are typical of background levels in Ontario.

Road Dust. Most of the road dust samples detected metals (with the exception of silver) and radionuclides. These values were used for comparative purposes and appeared consistent with the soil data.

Exterior Surface Dust. Metal levels for exterior surface dust were not significantly different than those found at the Marmora Township Office. These values were used for comparative purposes and appeared consistent with the soil data.

Outdoor Dustfall. Of the ten outdoor dust sample locations, only two locations detected arsenic. Both of these sample locations were adjacent to the Deloro Mine Site. Lead is the only contaminant with a dustfall criteria value. The value measured for lead did not exceed the lead dustfall criteria. These outdoor dustfall values were used for comparative purposes and appeared consistent with the soil data.

Comparison of Field Data

The results of all environmental sampling were compared to assess whether there were any patterns. There were few patterns observed; no one group of individuals in the village was considered to be more exposed to arsenic or other metals than another (see bullet below for radiological data trends). Levels of metals in soil do not necessarily increase with proximity to the mine site. For areas where higher concentrations of arsenic were observed (such as the middle of the Village) (refer to Figure 3), higher concentrations of cobalt, lead, nickel, and silver were also observed.

Radon Gas

Fifty-seven homes participated in sampling for indoor radon gas. The results indicate that the living areas of 10 residences and the Deloro pumphouse have or may be close to having radon gas levels higher than the 1977 Federal/Provincial Task Force guidelines for radon, although within the range of variability of typical levels in Ontario. It is important to note that while the radon levels approached or exceeded the 1977 Federal/ Provincial Task Force Criterion, none of the measured values exceeded Health Canada's radon guideline; considered to represent a level at which remediation actions should be taken.

Outdoor radon gas was measured at 11 locations (10 places within the village and one in Marmora). For outdoor radon gas, the levels were typical of Ontario background conditions.

Gamma Radiation

More than 175,000 gamma radiation measurements were recorded. Gamma radiation surveys were conducted on 63 participating residential properties. Surveys were also conducted on: the Village park area and baseball field located west of O'Brien Road; the property near the Deloro Pump House; the Community Hall/Library building rear yard; on the accessible portions of the vacant lot near the main gate to the former mine site; along the rear laneway east of O'Brien Road; along the Deloro Dam roadway; along a series of recreational trails located to the east of the main Village; along the western perimeter fence line of the former mine site; and, in several open fields adjacent to the homes in the northern part of the study area.

The 1977 Federal/Provincial Task Force guidelines for gamma radiation was exceeded on only one property, specifically the vacant lot near the main entrance to the former mine site. The radiation levels decrease rapidly with distance from the mine site. The estimated radiation dosage for current conditions is not a health concern.

Three areas (4 to 15 m^2 in size) of elevated gamma radiation levels were encountered in the Village. These levels were below the 1977 Task Force criteria (see Appendix 2 for the Ministry's Action Plan)

Study Objective Two:
What are the possible exposures that residents might have to these contaminants and how likely would it be for these exposures to happen?

In order to determine if residents are exposed to contaminants, the following was conducted:

- Tests for arsenic in urine for those Deloro residents willing to participate in the study, and in a comparison control community, Havelock, Ontario. Arsenic in urine is recognized in the medical community as the best indicator of recent environmental exposure to arsenic.

- A environmental health and risk factor questionnaire was administered to Deloro residents to profile the socio-demographics, health, environmental characteristics and diet patterns for comparison with the arsenic in urine data to determine if there were any relationships. This included a robust statistical analysis.

- Prediction of exposures for adults and children through multi-pathway exposure analysis using the most current modelling methods available.

Urinary Arsenic Study

A biological monitoring program was conducted to measure and assess the health significance of environmental exposure to arsenic. The program involved urinary arsenic tests, administration of a detailed risk factor and health status questionnaire and determination of total and speciated arsenic levels in urine. Urinary arsenic tests are recognized in the medical community as the best method of measuring recent environmental exposure to arsenic. It is also the most sensitive for looking at low level exposures and the actual bodily dose to people. It is also the only method for which the health significance of the levels can be judged because some guidelines exist for total arsenic and there is information on speciated arsenic which can serve as a benchmark for health interpretation.

Note: It has been acknowledged in the literature that much of the "total arsenic" could be a measure of exposure to organic sources (e.g., seafish meal) and these sources possess no danger to the health of the person. However, "speciated (inorganic) arsenic", is identified in the literature as potential cause for concern, at least with respect to some acute symptoms and some chronic diseases. It is this latter measure that was the main focus of the urinary arsenic analysis.

Havelock, Ontario, was chosen as a comparison community (i.e. control) for the urinary arsenic tests since it is far enough away from Deloro to not be affected by mine activities. Participation in the biological monitoring component was voluntary in both communities. There was a very high participation rate in the study, which meant the community was well characterized, uncertainty reduced, and reliability in the overall findings for the village increased.

Urinary Arsenic Tests

Urine samples were collected from 121 volunteers in the Village of Deloro (8 out of every 10 people participated) and 53 volunteers from Havelock. An environmental health risk questionnaire (completed for 140 volunteers for Deloro and 54 volunteers from Havelock) was used to determine if there was a link between urinary arsenic levels and information obtained from the risk questionnaire such as diet, source of drinking water, occupation, and length of residence. Since almost the entire populations of Deloro and a good representation of Havelock were included in the study, the results are considered quite reliable for a study of this nature.

Overall, the urinary arsenic results for both total and speciated arsenic analyses and for Deloro and Havelock were well below those normally associated with adverse health effects. There were, however, in both communities, a few people (four in Deloro and one in Havelock) whose results for urinary arsenic were slightly above the normal range. Detailed analysis of the reported environmental health risk information from these residents showed no adverse health effects or unusual exposures. However, as a measure of prudence the health experts on the study team advised these individuals to consult with their family doctors. In addition, comprehensive information packages were provided to each individual's family physician.

Levels of arsenic in urine (total and speciated) in Deloro residents are essentially the same as those in the comparison (non-exposed) community. The distribution of urinary arsenic levels in Deloro residents was also very similar to the distribution in Havelock residents and there was no statistical difference in mean values for all the arsenic results between the two communities. In short, there was nothing unusual about any of the urinary arsenic findings.

Therefore there was no meaningful difference found in levels of arsenic in urine between Deloro and the comparison (unexposed) community of Havelock, a town where there is no known arsenic contamination. In other words, arsenic exposure in Deloro is essentially that of a community where no environmental arsenic exposure is expected.

Levels of arsenic in urine in Deloro are also not indicative of any excess levels of illness (as observed by the Deloro / Havelock residents via self-reporting). In other words, there was no relationship between the level of arsenic in an individual's urine and whether or not he/she had reported some kind of health problem on the questionnaire.

There was no demonstrable relationship between arsenic levels in residential yards and garden soil and arsenic levels in people's urine. In other words, higher arsenic values on a property did not lead to a higher urinary arsenic level in the resident(s) of that property.

There was no demonstrable link between levels of arsenic in urine and characteristics of the residents such as the length of time living in Deloro, age, income, education, location of residence, use of vegetable gardens and use of well water.

The average levels of arsenic in urine of residents from Deloro were much less than the averages reported for other people exposed to significant sources of arsenic (such as mining/smelting, occupational, etc.) as reported in the scientific literature.

Study Objective Three:
What is the likelihood of health effects from exposure?

Predictive Exposures and Risks

In order to determine if health effects could result from exposure to some levels of contaminants, a predictive risk assessment was completed.

Risk characterization for residents of Deloro

Arsenic and Other Metals

Everyone in Ontario is exposed to arsenic, lead and other metals and has a certain level of risk. This is because trace elements like arsenic are present in our environments wherever we live. When people living anywhere are exposed to arsenic, the greatest potential health risk is the development of skin cancer and, to a lesser degree, lung cancer. Studies elsewhere have also shown that high arsenic exposures are associated with internal cancers such as bladder cancer.

Exposure and risk estimates for Deloro residents were compared against the exposure and risk estimates for typical Ontario adults and children and it was found that overall exposures to arsenic were only marginally greater for Deloro.

Estimated arsenic exposures are not measurably higher than those of typical Ontario residents.

Overall predicted exposures and risks for arsenic were only slightly greater when compared to estimates for the typical Ontario resident. For example, predicted maximum cancer risk for arsenic in Deloro from all pathways totaled was less than 0.2X higher than the maximum risk for a typical Ontario arsenic exposure (1.17 per 1000 for Deloro versus 0.963 per 1000 for Ontario). Most importantly, the percent contribution of exposure or dose from soil and dusts (dermal, ingestion and inhalation) was small when compared to arsenic in the normal daily diet. The presence of arsenic in the Ontario diet is due to its natural occurrance as a trace element in the earth and its uptake into crops. There are also various forms of arsenic in food which are considered non-toxic or less toxic than other forms.

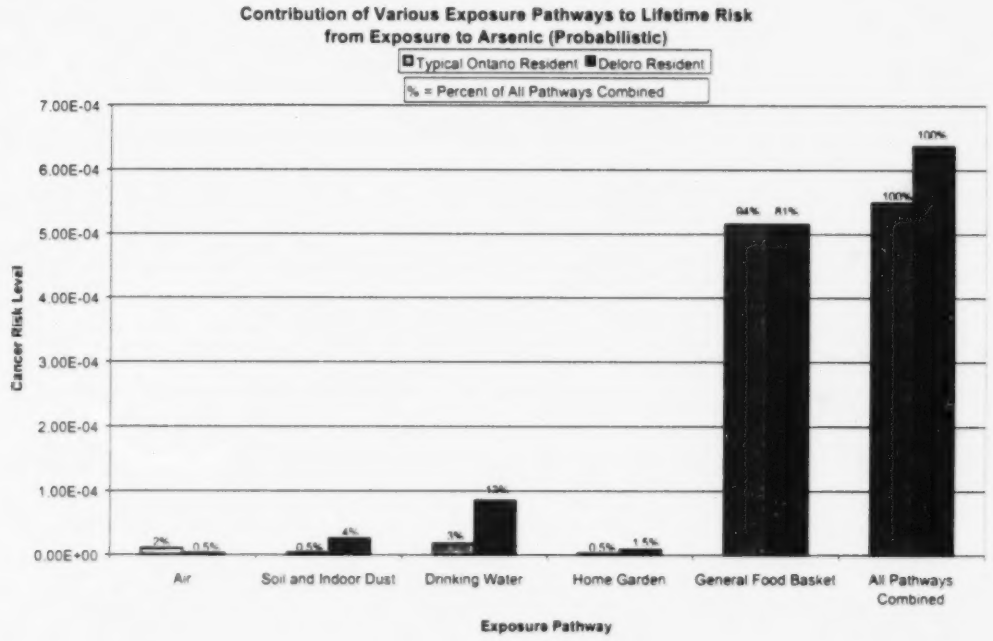
Predicted cancer and non-cancer risk levels were only slightly higher for Deloro residents than for a person living elsewhere in Ontario. For example, it was estimated that roughly 80% of lifetime exposure to arsenic in Deloro is from the normal Ontario food basket as compared to roughly 4% for soil and indoor dust combined. The relative contribution of specific pathways to total lifetime risk (e.g. backyard vegetables, diet, soil) is shown in Figure 4. The combined risk from soil, indoor dust and home garden produce is 1/10th that of the regular Ontario food basket. Furthermore, the levels of risk for each of the soil and indoor dust, and backyard vegetable consumption were found to be in the range of risk which is considered negligible.

If all soils in Deloro were replaced with background soils, overall risks would be reduced by only 2-4%.

Deloro residents would not experience risks from exposure to lead that were significantly greater than typical Ontario residents. No adverse health effects would be expected to occur a the levels of lead found in the village as these levels were not unusually high.

Levels of cobalt and silver in the village of Deloro are not high enough to result in any measurable health risk. Risks from exposure to nickel in Deloro were comparable to those for typical Ontario residents.

Figure 4. Comparison of estimated cancer risks from arsenic by various pathways for Deloro and typical Ontario residents



Radiological

The radiological doses and lifetime risks predicted for current residents of the Village of Deloro were comparable to and within the range of doses and risks for typical Ontario residents from natural background radioactivity.

The major contributor to lifetime risk was radon, which accounted for about 70 percent of the average lifetime risk for a Deloro resident. Gamma radiation and water ingestion accounted for about 17 percent and about 11 percent of the average lifetime risk, respectively. Risk from inhalation of airborne dust and ingestion of soil, dust, garden produce accounted for less than 1 percent of the total lifetime risk. The estimated risk from water ingestion is highly uncertain and in all likelihood is overestimated, since the risk calculation is driven by the laboratory detection limits (the water concentrations were below the detection limit). There is no significant radioactivity in the village, and the water is safe.

Although the estimated doses and resulting risks to residents of the Village are comparable to typical background doses and risks, there is still an indication of higher risks from gamma radiation closer to the mine site. Higher indoor radon levels may be of natural origin.

Cancer Incidence and Mortality in Deloro and Hastings County

The Hastings County Health Unit undertook an assessment of cancer incidence and mortality rates in Deloro and the population of the surrounding area (including downstream along the Moira River) from 1980 to 1995. Reviews were conducted for the following twelve cancer sites: lip; oral cavity and pharynx; stomach; colorectal; pancreas; nasal cavity; lung; breast; cervix; prostate; bladder; kidney; leukemia and all sites. The site specific cancers were selected because they had been identified in the literature as being potentially associated with the contaminants present at the Deloro Mine Site or because they were relatively common cancers which could provide useful comparisons. Skin cancer was excluded because diagnosis and reporting of non-melanoma skin cancer is incomplete and unreliable. Cancer cases for Deloro were grouped with other municipalities because there were few too cases in Deloro to release the information without violating guidelines for confidentiality or to calculate reliable statistics.

The study found significantly high and low standardized incidence and mortality rates for at least some cancers in every area within Hastings and Prince Edward Counties Health Unit. The following comments focus on significant findings for Deloro and Surrounding Areas.

- With respect to mortality, summarized standardized mortality ratios were high for lung cancer and leukemia in males compared to Ontario, but not when compared to other areas in Hastings County. There was no evidence of a statistically significant trend over time, although leukemia mortality rates appeared to decrease from the early 1980s to the mid-1990s. Females had significantly low summarized standardized mortality ratios for leukemia and stomach cancer when compared to the province. The fact that the total number of observed leukemia deaths was almost exactly what would be expected suggests the cases were distributed unevenly between the sexes by chance.

- For Deloro and surrounding area, standardized incidence ratios were high for lung cancer in males compared to Ontario, but not when compared to other geographic areas in Hastings County. There was no evidence of a trend over time. Females had significantly low summarized standardized incidence ratios for stomach cancer and colorectal cancer.

- For the cancers studied, no incidence or mortality rate was high enough to suggest further, more detailed analysis, was warranted for either males or females.

Conservative Elements of the Study

Predictions of exposure and risk are only estimates and these estimates do not necessarily reflect any one person's actual exposure of risk. In fact, exposure will vary between people because of their different activities, the amount of time in contact with a substance, age (children tend to have higher exposures because of their smaller body weight). As a precaution in these studies various assumptions are made which tend to overestimate risk to a considerable degree.

This conservative assumptions include, for example:

- Use of the U.S. EPA toxicity factors and cancer slopes for calculating risk. These factors are considered by U.S. EPA as overestimating the risks. The expert peer review agreed that the risk values would be overestimated. There are large uncertainty or safety factors placed in these toxicity factors

- In many cases, environmental concentrations were not detectable. However rather than assume they are not there the study assumes that they are present at half the detection limit and based the risk calculations on this. Using a more sensitive method of analysis would likely demonstrate lower risks than were calculated.

- Although household swipe samples detected very little contamination in dust, the study team recognized that this was not an indication that contaminants were not present in homes. Vacuum samples were not collected because these methods tend to underestimate risk. Instead the study assumed that indoor dust was contaminated in relationship to the levels outside the house. Risk estimates were based accordingly.

- Backyard gardens sampled did not have the highest arsenic in soil levels. Therefore the risk assessment modelled what levels in fruits and vegetables might be in other areas of the village. In other words theoretical garden conditions were modelled that were not evident in the village.

- Risk estimates are based on a lifetime of exposure over 70 years. In most cases persons do not live in one area over their whole lifetime. As such for many people, this is another factor which overestimates the risk calculations.

- In the study chemical concentrations were assumed to remain unchanged in the future. This overestimates risk, since with the closure of the mine site, metals in the village should decrease over time, albeit slowly.

Conclusions

Levels of Contaminants

1. Sampling indicates that there are elevated levels of arsenic, cobalt and lead in soils and above-background levels of other contaminants including radon and gamma radiation in some localized areas of the village.

Safety

2. However, **the results of the risk study strongly indicate that there are no unsafe exposures or adverse health effects associated with the contamination in the village**. Although the levels of arsenic and other metals were found to be elevated due to the past century of industrial activity at the mine, all of the analyses and expert opinion supports the conclusion that under the range of conditions considered **it is safe to reside in the village and its homes**.

Figure 1 – Health Study Framework

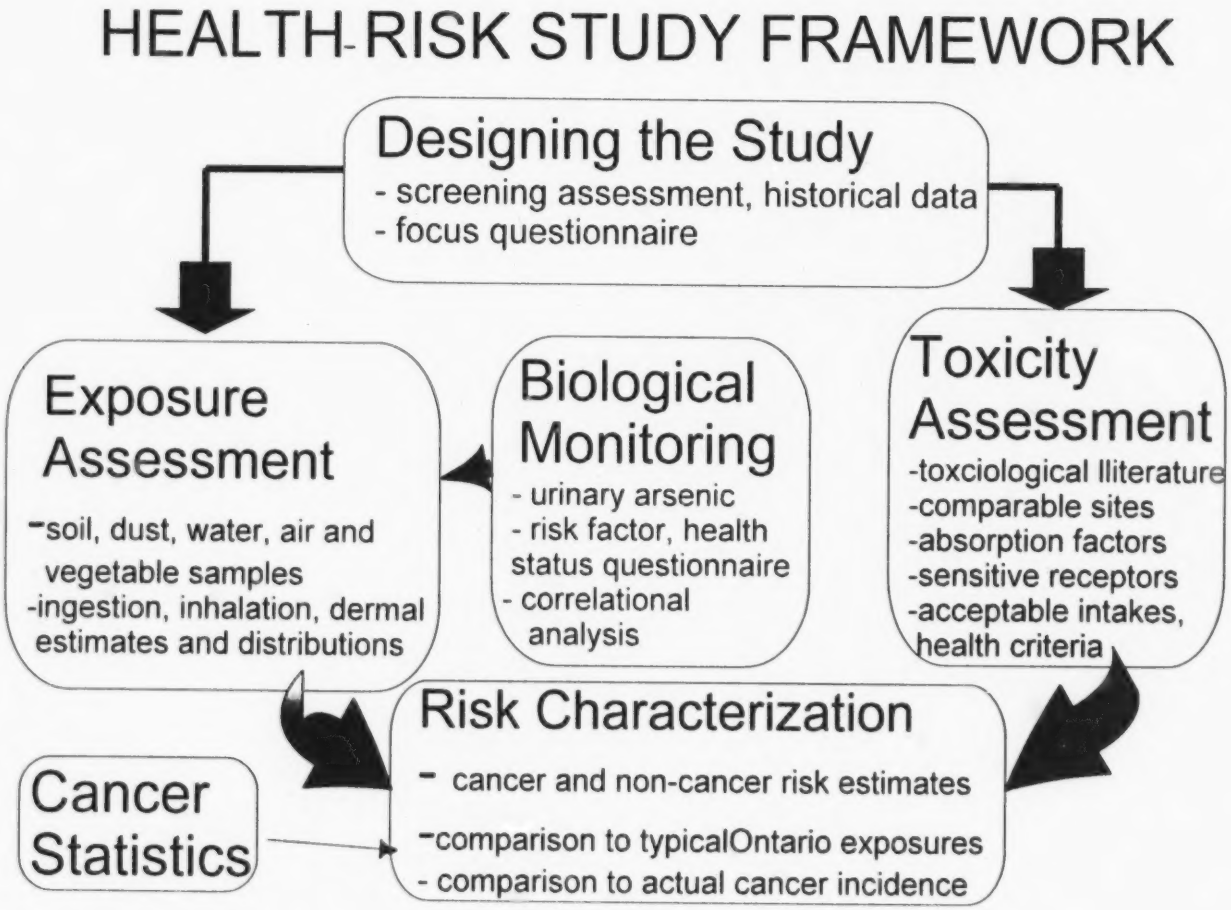
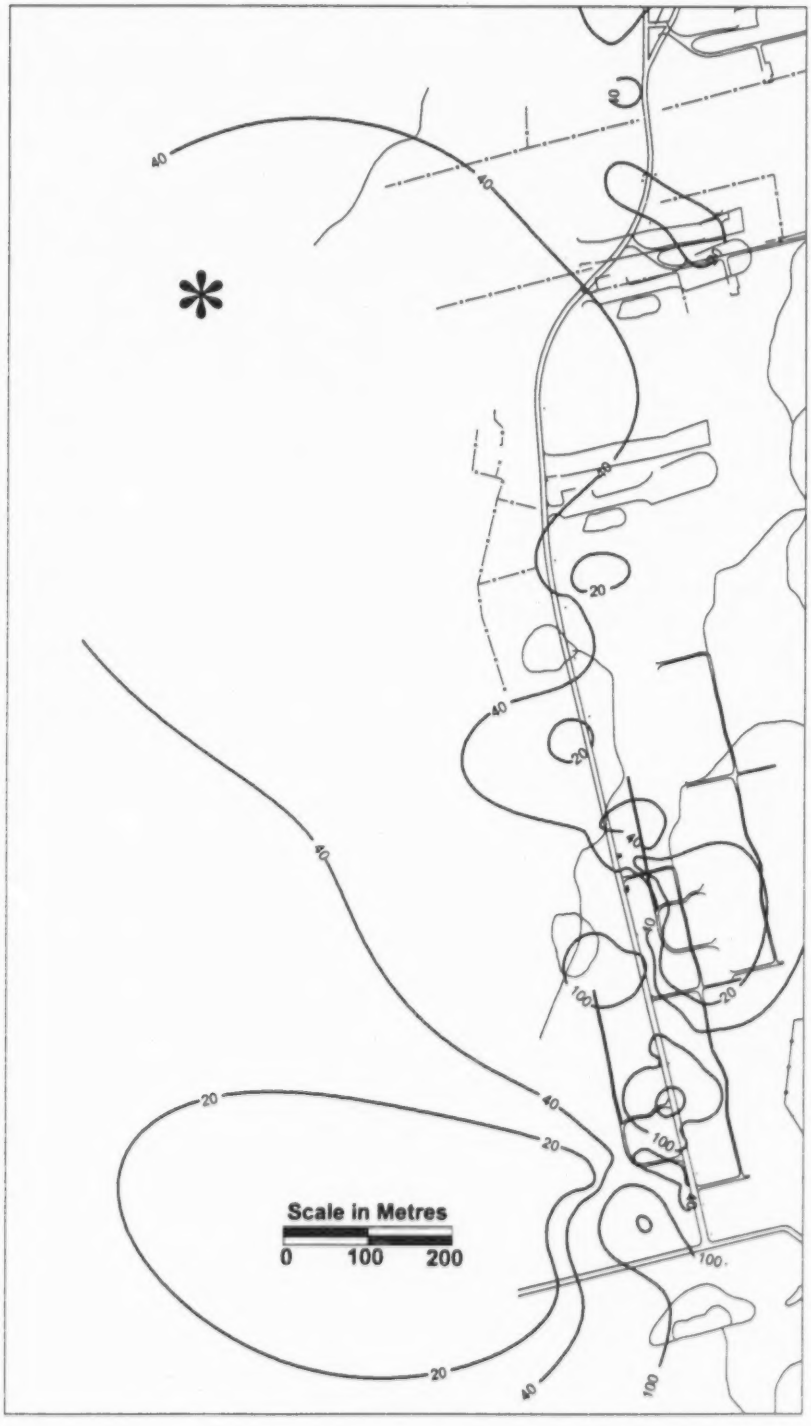


Figure 2-- Village of Deloro Zone Delineation

Figure 3 – Arsenic in soil in Deloro



Appendix 1 – Biographies
Ministry scientists, consultants, and peer reviewers

Technical Steering Committee

Murray Dixon is a Toxicity Assessment Scientist with the Ministry of the Environment. He holds his Honours B.Sc. and his M.Sc in Botany, both from the University of Toronto. He has been with the Ministry of the Environment for 13 years. He has studied a wide range of contaminants during his tenure at MOE, including in-depth experiments into the effects of arsenic on plants.

Scott W. Fleming is Senior Toxicologist within the Standards Development Branch of the Ontario Ministry of the Environment. He obtained his graduate degree from the University of Toronto in 1985, where his research studies were in the field of neurotoxicology. Mr. Fleming is a recognized Canadian expert in the fields of toxicology and human health risk assessment of environmental contaminants. He has conducted a number of large-scale community health risk studies within the province of Ontario and co-author of the Ministry's Guidance on Site Specific Risk Assessment for Contaminated Sites. His award-winning work on development of environmental standards for lead formed the scientific basis for the tough new standards on this substance in Ontario. In addition, he has developed environmental and occupational exposure limits for a variety of toxic substances and has published numerous scientific reports and learned articles.

Mr. Glen Hudgin is currently Director of Public Health Inspection for the Hastings and Prince Edward Counties Health Unit. He was born in Picton, Ontario. He is a Canada Certified Public Health Inspector. He earned his Bachelor's Degree in Environmental Health from Ryerson Polytechnical University. He was first employed as a Student Public Health Inspector in the Picton Office of the Hastings and Prince Edward Counties Health Unit. He carried out one of the first bacteriological water quality studies of the Bay of Quinte in 1970. Previously, Mr. Hudgin was employed as a District Public Health Inspector for the city of North York Health Department. When there, he carried out a bacteriological study of the North York segments of the Don River, Humber River and Black Creek.

Dr. Michael A. McGuigan, MD, MBA is an Associate Professor of Pediatrics, Pharmacology, and Health Administration in the Faculty of Medicine at the University of Toronto. A graduate of McGill University medical school, he finished his post-graduate training in clinical pharmacology and toxicology at Harvard University's Children's Hospital in Boston and was certified as a medical toxicologist by the American Board of Medical Toxicology. In 1980, Dr. McGuigan assumed the position of Medical Director of the Ontario Regional Poison Information Centre at The Hospital for Sick Children in Toronto. He is past-President of the American Academy of Clinical Toxicology and current President of the Canadian Association of Poison Control Centres.

Dr. Lynn Noseworthy has been a Medical Officer of Health since 1991 at the Hastings and Prince Edward Counties Health Unit. She completed her Doctor of Medicine Degree in 1979 at Memorial University of Newfoundland. In 1987, Noseworthy went on to complete her Master of Health Science Degree in Community Health and Epidemiology at the University of Toronto.

Jim Ritter is the Ontario Ministry of the Environment's Project Manager and Operations Engineer for the Deloro Mine Site Rehabilitation Project. He started his career working for the Federal Department of National Defence and has also held positions with the Ministry of Labour, the Industrial Health & Safety Branch and private industry. A Civil Engineer and a Canadian Registered Safety Professional, Mr. Ritter has been working on mine rehabilitation efforts in Deloro since 1992.

Arthur Scott is an expert in radon and radioactivity who currently works with the Ontario Ministry of Labour's Radiation Protection Service. Prior to joining the Ministry, Mr. Scott directed field research on radon for the U.S. Environmental Protection Agency and oversaw radiation cleanup programs in Elliot Lake, Ontario and Uranium City, Saskatechewan for Canada's Atomic Energy Control Board. He earned his M.A. in Physics and M.Sc. in Radiation Biology and Radiation Physics at the University of London.

Dr. Lesbia F. Smith, M.D. is a senior medical consultant with the Ontario Ministry of Health's public health branch and an assistant professor at the University of Toronto's Department of Public Health Sciences. She specializes in environmental health and toxicology.

Adam C. Socha is Senior Advisor, Toxicology at the Standards Development Branch for the Ontario Ministry of the Environment. He has served as a toxicologist and technical manager with the MOE for over 12 years, specializing in human toxicology and the environmental behaviour of contaminants. Mr. Socha received his B.Sc. degree in pharmacology from the University of Toronto in 1983 and his M.Sc. degree in toxicology and physiology from the Ontario Veterinary College, University of Guelph in 1986. He is a member of the Society of Environmental Toxicology & Chemistry and the Society of Toxicology of Canada.

Consulting and Analytical Expertise

CH2M Gore & Storrie Limited is an employee-owned, Canadian-controlled corporation formed in 1995 through the merger of CH2M HILL Engineering Ltd. and Gore & Storrie Limited, both recognized leaders in the field of environmental engineering. With the combined resources of more than 300 employees Canada-wide, CG&S offers a complete range of environmental services and technologies to our clients across Canada and in the global market. The CG&S team of engineers, planners, hydrogeologists, scientists, and technical specialists is committed to providing environmental consulting services in all aspects of water, wastewater, and waste management for public and private sector clients. Our dedication to safeguarding the environment and being responsive to the increasingly specialized needs of our clients remains the cornerstone of our success.

Goss Gilroy Inc. (GGI) is a privately-owned Canadian company established in 1981 to provide quality management consulting services to private and public sector organizations. We provide our clients with services and technical expertise in the areas of surveys and statistical consulting, project and program evaluation, market research, information technology, and comprehensive and internal audits. The technical strength of our firm's professional staff is augmented by operational and management experience gained from working closely with industry and government. Our projects cover subject areas including health, environment, natural resource management, industry, agriculture, technology transfer, research and development, employment, and regional economic development.

Cantox Environmental Inc. is a science-based consulting firm specializing in providing expert advice to clients on toxicology issues related to human health, the environment and regulatory affairs. Our scientific staff, in five offices across Canada and the United States, includes more than 50 professionals with experience that encompasses diverse areas of human and aquatic toxicology, environmental fate and modelling, human health and environmental risk assessment, and risk communication. We have been providing a full range of consulting services to industry, government, trade associations, scientific organizations, financial institutions, and the legal profession for more than 15 years.

SENES Consultants Limited is a wholly-owned Canadian company that provides specialty services on a broad spectrum of projects that typically involve provision of expert advice on specific environmental issues; preparation of environmental and ecological risk assessments; site investigations; environmental audits; low-level radioactive and hazardous waste investigations and design of applicable management systems; assessment and cost–benefit analysis of environmental control technologies; preparation of facility audits and development of environmental quality management systems; aquatic ecosystem assessment and management; atmospheric chemistry, monitoring, and dispersion modelling; and various aspects of mining including environmental impact assessments, development of decommissioning plans, and assessment of acid mine drainage. We provide services to regulatory agencies from all levels of government as well as to private sector companies, industrial associations, and public organizations.

External Peer Reviewers

Dr. Charles Abernathy is a toxicologist for the U.S Environmental Protection Agency's Office of Water. He has carried out extensive scientific research on behalf of the Veterans Administration Medical Center in Washington D.C. for more than 10 years. The author of more than 70 scientific articles in professional journals, Dr. Abernathy holds a M.Sc. from the University of Kentucky and a Ph.D. from North Carolina State University. He also received postdoctoral training in pesticide toxicology at the University of California, Berkeley.

Dr. Henry S. Caplan is the Head of Physics and Engineering Physics at the University of Saskatchewan. In addition to being published in more than 100 academic journals and abstracts, Dr. Caplan is recognized as an expert in the analysis of radiation hazards and mitigating procedures for mine workers and the environment. He received his B.Sc. in Experimental Physics and a Ph.D. in Nuclear Physics from the University of Glasgow.

Dr. Willard Chappell is a Physics Professor at the University of Colorado. The founder and Director of the Center for Environmental Sciences at the University of Colorado between 1979 and 1989, he is the co-chair and principal organizer for the Society of Environmental Geochemistry International Conferences on Arsenic Exposure and Health Effects. Dr. Chappell holds a Ph.D in Physics from the University of Colorado.

Mark J. Gardiner is the Technical Supervisor of the Port Hope Field Services Office (PHFSO) of the Low-Level Radioactive Waste Management Office (LLRWMO). In this capacity he oversees environmental monitoring, site characterization and project planning services for PHFSO activities within the mandate of the LLRWMO in Canada. Mr. Gardiner has been with the LLRWMO for over 10 years, specializing in environmental monitoring program development, environmental investigation/remediation planning and facility licensing. He is currently acting as a technical advisor to Natural Resources Canada in the development of a long-term management plan for historic low-level radioactive wastes in the Port Hope area. Mr. Gardiner received his B.Sc. in Physical Chemistry from Trent University.

Raymond E. "Buck" Grissom, Jr., Ph.D. is a senior toxicologist at the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, in Atlanta, Georgia. He provides primary peer review and analysis of health consultations written by staff at the ATSDR. He is responsible for providing expert toxicological and technical advice and appropriate recommendations about potential health impacts resulting from emergency and non-emergency situations involving the release or potential release of hazardous substances. He prepares written health consultations for ATSDR headquarters, regional field personnel, and other government agencies (federal, state, and local). He represents ATSDR at conferences, public meetings, and meetings with representatives of other federal agencies, state and local agencies. His other responsibilities include writing manuscripts for publication, and reviewing, evaluating, and critiquing the work of other environmental and health science professionals.

Dr. Grissom is a graduate of North Carolina State University at Raleigh, North Carolina. He is a member of the American Association for the Advancement of Science, Sigma Xi, Society of Toxicology, the Southeast Chapter of Society of Toxicology, and the Gamma Sigma Delta Honor Society.

Dr. Chris Le is an Associate Professor with the University of Alberta's Department of Public Health Sciences whose expertise includes ultrasensitive assays for DNA damage and environmental contaminants; chemical speciation of trace elements; the exposure and health effects of arsenic; and biomarkers.

Dave McLaughlin is an adjunct professor at the University of Toronto's Faculty of Forestry and an Investigations Co-ordinator with the Ontario Ministry of the Environment's Phytotoxicology and Soil Standards Section. He has 21 years experience in environmental investigations and has published numerous reports and scientific papers on environmental contaminants in soil and the effects of pollution on plants and forest ecosystems. Mr. McLaughlin earned his B.Sc. and M.Sc. in Forestry from the University of Toronto.

Dr. Bliss Tracy has been a research scientist with Health Canada since 1978. He received his B.Sc. from the University of New Brunswick and his Ph.D. in nuclear physics from McMaster University. Mr. Tracy's recent work includes projects related to radionuclide monitoring for the Comprehensive Test Ban Treaty and to preparations under the Federal Government's Nuclear Emergency Plan.

Appendix 2– The Ministry's Action Plan

When the Ministry of the Environment launched the environmental health risk study it made a commitment to define the extent of the contamination, possible exposures and health implications. It also committed to take necessary actions to address those problems.

Comprehensive environmental sampling and urine testing results show that the Village of Deloro is a safe community. While none of the sampling and analysis conducted in the village showed a need for immediate remedial actions, a number of actions are being implemented to address issues identified in the study.

MAINTAINING DRINKING WATER SAFETY

- The ministry will continue its monitoring of the water supply, and as a measure of prudence, has increased monitoring of the Deloro communal well as part of the provincial Drinking Water Surveillance Program (DWSP). This rigorous water quality surveillance program provides detailed and ongoing documentation on the progress and performance of municipal water treatment plants across the province. The program detects subtle changes in water quality and as such acts as an alert system, notifying authorities of any exceedance of the Ontario Drinking Water Objectives. The Deloro communal well was added to the program in January 1999.

REDUCING RADON

- Testing for radon, a radioactive substance that is a gas, indicated that several homes tested in the village have or may have radon in excess of the 1977 Federal/ Provincial Task Force criterion for radon; however none of the measured values exceeded Health Canada's radon guideline. Radon levels were all within the range of naturally occurring levels typically found across Ontario. The ministry will work directly with all residents with radon approaching or in excess of the 1977 criterion to reduce exposure. This may involve additional monitoring and / or the installation of radon gas venting systems.

REMOVING POCKETS OF SOIL

- There were three small pockets (covering an area of no more than a few square metres) of slightly elevated gamma radiation levels. The ministry will remove these small pockets of soil and place them on the mine site to reduce the potential spread of radioactive contamination in the environment. These materials will be dealt with in the site remediation program. The vacant lot adjacent to the entrance to the mine site will also be dealt with in the site remediation program.

FENCING THE MINE SITE

- The ministry has made it clear through fencing and warning signs that trespassing on the mine site is strictly prohibited. There are some areas on the mine site where very high levels of arsenic (much higher than in the village) exist. There are also areas of radiation from low level radioactive waste materials. Trespassing on the mine site property prior to completion of the remediation work was identified in the study to result in a significant increase in risk. The ministry will upgrade the fencing and signage of the mine site property.

The total cost of implementing the action plan is about $1.66 million.

Appendix 3– Questions and Answers

Is it safe to live in the village of Deloro?

Yes. Comprehensive environmental sampling and urine testing results show that Deloro is a safe community.

While the study confirms that there is contamination in the community, there is no significant link between this contamination and health risks to residents.

The water supply is safe.

Is it safe to eat homegrown vegetables from Deloro?

Vegetables grown in Deloro are safe to eat. While there are elevated levels of arsenic within the soil, it does not contaminate vegetables. Sampling of garden vegetables shows there is no significant difference between garden vegetables from Deloro and vegetables grown in typical Ontario soil.

Is Deloro's drinking water safe?

Yes. Deloro's drinking water is safe.

Deloro has one of the most comprehensively sampled water supplies in the province. Testing was intensified during the study and confirmed to be safe and within Provincial Drinking Water Objectives.

The use of lead alloy pipes is a concern in a small number of older homes. Homeowners with lead pipes are encouraged to let the water run for an appropriate period of flushing to rid the system of standing water prior to drinking, beverage preparation, and cooking.

Did urine samples supplied by Deloro residents indicate any signs of arsenic?

Despite the elevated levels of arsenic in Deloro's soil, residents do not appear to have higher levels of urinary arsenic. The urine samples provided by Deloro residents contained arsenic levels that were comparable to those provided by residents in Havelock.

Everyone in Ontario is exposed to a certain amount of arsenic. It is present in air, soil and everyday food items.

The results suggest that the greatest source of arsenic for Deloro residents is their regular diet, as it is for all residents of Ontario.

Arsenic levels found in the air were actually lower than the average background levels in Ontario.

Is arsenic present in people's homes?

While the study concludes that arsenic is present in carpets and indoor dust, it did not find a significant link between this contamination and health risks.

The Ministry was thorough in its testing. Sampling from participating residences typically included:

- Indoor swipes for dust at two locations were tested for metals (including cobalt, lead, nickel, silver, arsenic and uranium) and for alpha and beta radioactivity;
- Indoor dustfall at one location was tested for metals, alpha and beta radioactivity;
- Indoor air at two locations was tested for metals;
- Drinking water for metals and radionuclides
- Soil for metals and radionuclides
- Biological monitoring (urine testing) for total and speciated arsenic levels; and,
- Radon gas testing at two locations.

Swipe samples are considered to be the most accurate indicator of exposure. Measurement of indoor dust can also be measured via a vacuum pump method but tends to underestimate risks.

The risk assessment at Deloro was based on standard ratios of indoor dust to outdoor dust because a significant number of the indoor swipe samples contained arsenic in levels that were too low to detect. The method used ensured that indoor dust concentration would not be underestimated.

Were radiation levels tested in the Village?

Yes. More than 175,000 gamma radiation measurements were recorded.

The study determined that overall, radiation risks to residents are within the range of the natural background levels that are typically found in Ontario. Gamma radiation levels above background were found adjacent to the western fence of the mine site and at one vacant property. In addition, there were three small pockets within the Village.

While the levels found were not deemed to pose an immediate health risk, the Ministry of the Environment plans to remove the affected soil to a contained section on the mine site.

Tests for indoor radon gas identified several residences in the village that have or may have radon gas levels in excess of the Federal/Provincial Task Force criteria for radon in houses. None of the measured values exceeded Health Canada's radon guideline. The Ministry will work directly with all affected residents to reduce radon exposures. It should be noted that one out of every twenty homes in Ontario is typically susceptible to radon contamination.

Does arsenic contamination in Deloro pose a cancer risk?

The cancer risk from arsenic contamination in Deloro is considered to be comparable to the typical risk for Ontario residents.

A typical Ontario cancer risk is estimated to be 0.963 cases per 1000 people, whereas the risk in Deloro is estimated to be 1.17 cases per 1000 people. This estimate suggests that the maximum risk within Deloro is less than 0.2 times higher than the typical risk for Ontario.

How credible are the results of this study?

The Environmental Health Risk Study in the Village of Deloro was the most comprehensive of its kind in Ontario.

The study's conclusions are based on thousands of samples -- including soil, indoor and outdoor air and dust, drinking water, radon gas, radioactivity, garden vegetables and a comparison of urine samples from Deloro and another Eastern Ontario community.

More than forty experts contributed to the study, including a number of North America's most senior scientists, toxicologists, engineers and medical doctors. The Ministry of the Environment designed the study in cooperation with the local Medical Officer of Health, the Ministry of Health, the Ministry of Labour and an internationally renowned physician who specializes pediatrics and toxicology.

Research was carried out with the assistance of four independent consulting firms and the final study was peer reviewed by top Canadian and U.S. experts on arsenic, radioactivity and health risk assessment to ensure the highest quality and reliability.

What action will the Ministry take to fulfill the recommendations made within this Health study report?

The Ministry plans to spend about $1.66 million to address the issues identified in the health study report. Priorities will include maintaining drinking water safety, improved security on the mine site, the removal of isolated pockets of soil and measures to reduce radon gas.

The Ministry's $1 million environmental health risk study is part of a larger $18 million effort to rehabilitate the abandoned mine site over the next three years.

Why did it take the Ministry so long to complete the study?

The Ministry of the Environment committed itself to providing Deloro residents with accurate information as soon as it was available. The time spent working on the study and having an expert panel of peers review it was necessary to ensure residents received reliable information.

The health and safety of Deloro residents is the Ministry's prime concern. Residents were assured during the sampling and analysis phase of the health study, that any samples that indicated an immediate health hazard would be reviewed with the medical doctors on the study's Technical Steering Team and communicated immediately to the affected residents. These experts did not find any results that suggested a need for immediate intervention.

Is the abandoned mine site safe?

No. The abandoned Deloro Mine Site is not safe. Over the years, the Ministry of the Environment has addressed many of the physical hazards left by past mining and industrial operations. However, the mine site is highly contaminated and it is unsafe to trespass on the property.